積雪変態アルベドプロセスモデルのグリーンランドへの適用

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Evaluation of Snow Metamorphism and Albedo Process (SMAP) model in Greenland

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Snow and ice on the Greenland Ice Sheet (GrIS) are melting abruptly in response to recent rapid changes in the Arctic climate system, which are mainly attributed to global warming. However, robust mechanisms of the rapid melting have not been clarified yet. In order to understand the mechanisms, we employ a one dimensional multilayered physical snowpack model named Snow Metamorphism and Albedo Process (SMAP) model. SMAP model takes energy balance, mass balance, snow settlement, phase changes, water percolation, and snow metamorphism into account. To simulate realistic snow albedo and solar heating profile in snowpack, SMAP model incorporates a physically based snow albedo model (Aoki et al., 2011), which uses simulated profiles of snow grain size and snow water equivalent, together with mass concentrations of snow impurities externally given from in situ measurements or aerosol transport models. As a first step of this study, using SMAP model, we simulated physical states of snowpack at the Swiss Camp (69°34' 06" N, 49°18' 57" W, 1149m a.s.l), which is located on the southwest part of the GrIS, for both 2002 and 2003 spring accumulation periods (from March to April for 2002 and from March to May for 2003). For model input data, we used wind speed, air temperature, relative humidity, surface pressure, downward shortwave radiant flux, and net radiant flux at the snow surface measured with the automated weather station (AWS) installed at the Swiss Camp (Steffen et al., 1996). In addition, we employed precipitation data obtained from ERA-Interim reanalysis data to drive SMAP model. Also, we assumed snowpack was pure, that is, no snow impurities were input. We validated model performance in terms of surface height change. The original version of SMAP model developed to simulate physical states of seasonal snow overestimated surface height change. Thus, we optimized four snow physical schemes related to new snow density, viscosity coefficient of snow, maximum mass fraction of water, and effective thermal conductivity of snow. This polar optimized version of SMAP model improved the model performance and reproduced more realistic surface height change during accumulation period. To obtain further improved model performance and to simulate abrupt melting in the next phase of this study, it is necessary to reduce model uncertainties on multifarious physical processes of polar snow through further observations and modeling.

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References

Aoki, Te., K. Kuchiki, M. Niwano, Y. Kodama, M. Hosaka, and T. Tanaka, Physically based snow albedo model for calculating broadband albedos and the solar heating profile in snowpack for general circulation models, J. Geophys. Res., 116, D11114, doi:10.1029/2010JD015507, 2011.

Steffen, K., J. E. Box, and W. Abdalati, “Greenland Climate Network: GC-Net”, in Colbeck, S. C. Ed. CRREL 96-27 Special Report on Glaciers, Ice Sheets and Volcanoes, trib. to M. Meier, pp. 98-103, 1996.